



## REMR TECHNICAL NOTE CS-MR-3.9

## CRACK REPAIR METHOD: EPOXY INJECTION

PURPOSE: To provide guidance on use of epoxy injection to repair cracks in concrete. (NOTE: Before selecting any method for repair of cracks, REMR Technical Note CS-MR-3.1, "Selection of a Crack Repair Method," should be reviewed.)

DESCRIPTION: This method can be used to repair cracks as narrow as 0.002 in. The method generally consists of drilling holes at close intervals along the cracks, in some cases installing entry ports, and injecting the epoxy under pressure. For massive structures, an alternative procedure consists of drilling a series of holes, usually 7/8 in. in diameter, that intercept the crack at a number of locations. Typically, holes are spaced at 5-ft intervals.

EQUIPMENT, TOOLS, AND PERSONNEL REQUIREMENTS: A concrete drill, an epoxy injection system, a means of cleaning holes and cracks, and normal hand tools are required. One man can repair cracks using this method, but a two- or three-man operation is more efficient. Epoxy injection requires personnel with a high degree of skill for satisfactory execution.

APPLICATIONS AND LIMITATIONS: Epoxy injection has been successfully used in the repair of cracks in buildings, bridges, dams, and other types of concrete structures. However, unless the crack is dormant (or the cause of cracking is removed, thereby making the crack dormant), it will probably recur, possibly somewhere else in the structure. If the crack is active and it is desired to seal it while allowing continued movement at that location, a sealant or other material that allows that crack to function as a joint must be used. Application of this method may also be limited by the ambient temperature.

In the specific case of delaminated bridge decks, epoxy injection can be an effective intermediate-term repair method. In this case, steps a, b, and f outlined below are omitted. The process is terminated at a specific location when epoxy exits from the crack at some distance from the injection ports. This method does not arrest ongoing corrosion.

STEP-BY-STEP PROCEDURE:

- a. Clean the cracks. The first step is to clean cracks that have been contaminated. Oil, grease, dirt, or fine particles of concrete prevent epoxy penetration and bonding. Preferably, contamination should be removed by flushing with water or some other specially effective solvent. The solvent is then blown out using compressed air or adequate time is provided for air-drying.
- b. Seal the surface. Surface cracks should be sealed to keep the epoxy from leaking out before it has gelled. Where the crack face

cannot be reached, but where there is backfill, or where a slab-ongrade is being repaired, the backfill material or subbase material is often an adequate seal. A surface can be sealed by brushing an epoxy along the surface of the crack and allowing it to harden. If extremely high injection pressures are needed, the crack should be cut out to a depth of 1/2 in. and width of about 3/4 in. in a V-shape, filled with an epoxy, and struck off flush with the surface. If a permanent glossy appearance along the crack is objectionable and if high injection pressure is not required, a strippable plastic may be applied along the crack. When the job is completed, the dry filler can be stripped away to expose the gloss-free surface.

c. Install the entry ports. Three methods are in general use:

1. Drilled holes--fittings inserted. Historically, this method was the first to be used, and is often used in conjunction with V-grooving of the cracks. The method entails drilling a hole into the crack, approximately 3/4 in. in diameter and 1/2 to 1 in. below the apex of the V-grooved section, into which a fitting such as a pipe nipple or tire valve stem is bonded with an epoxy adhesive. A vacuum chuck and bit are useful in preventing the cracks from being plugged with drilling dust.
2. Bonded flush fitting. When the cracks are not V-grooved, a method frequently used to provide an entry port is to bond a fitting flush with the concrete face over the crack. This flush fitting has a hat-like cross section with an opening at the top for the adhesive to enter.
3. Interruption in seal. Another means of providing entry is to omit the seal from a portion of the crack. This method can be used when special gasket devices are available that cover the unsealed portion of the crack and allow injection of the adhesive directly into the crack without leaking.

d. Mix the epoxy. This is done either by batch or continuous methods. In batch mixing, the adhesive components are premixed according to the manufacturer's instructions, usually with the use of a mechanical stirrer, like a paint mixing paddle. Care must be taken to mix only the amount of adhesive that can be used prior to commencement of gelling of the material. When the adhesive material begins to gel, its flow characteristics begin to change, and pressure injection becomes more and more difficult. In the continuous mixing system, the two liquid adhesive components pass through metering and driving pumps prior to passing through an automatic mixing head. The continuous mixing system allows the use of fast-setting adhesives that have a short working life.

e. Inject the epoxy.

1. Hydraulic pumps, paint pressure pots, or air-actuated caulking guns can be used. The pressure used for injection must be

carefully selected. Increased pressure often does little to accelerate the rate of injection. In fact, the use of excessive pressure can propagate the existing cracks, causing additional damage.

2. If the crack is vertical, the injection process should begin with pumping epoxy into the entry port at the lowest elevation until the epoxy level reaches the entry port above. The lower injection port is then capped, and the process is repeated at successively higher ports until the crack has been completely filled and all ports have been capped.
  3. For horizontal cracks, injection should proceed from one end of the crack to the other in the same manner. The crack is full if the pressure can be maintained. If the pressure cannot be maintained, the epoxy is still flowing into unfilled portions or leaking out of the crack.
- f. Remove the surface seal. After the injected epoxy has cured, the surface seal should be removed by grinding or other means, as appropriate. Fittings and holes at entry ports should be painted with an epoxy patching compound.

ENVIRONMENTAL CONSIDERATIONS: Reasonable caution should guide the preparation, repair, and cleanup phases of any crack repair activities involving potentially hazardous and toxic chemical substances. Manufacturer's recommendations to protect occupational health and environmental quality should be carefully followed. In instances where the effects of a chemical substance on occupational health or environmental quality are unknown, chemical substances should be treated as potentially hazardous and toxic materials.

REFERENCES:

- a. Maintenance and repair of concrete and concrete structures. US Army Corps of Engineers, Washington, DC, 1979. Engineer Manual 1110-2-2002.
- b. Causes, evaluation, and repair of cracks. ACI Committee 224. In: Journal of the American Concrete Institute, Vol 81, No. 3, American Concrete Institute, Detroit, MI, 1984. ACI224.1R-84.